the advantages of exploring free flight and shared-separation authority in a full-mission study environment.

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Enabling Cockpit-Based Self-Separation

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Data from capacity studies suggest that the National Airspace System (NAS) will reach its capacity limits with the current centralized Air Traffic Control (ATC) system within the next 2 decades. The goals of this effort were to design and develop prototypes of flight deck tools to support airborne management of separation and to evaluate the feasibility of shifting flight deck and ATC roles and responsibilities relating to the management of separation. The concept of Free Flight introduces many challenges for aviation operations in the air and on the ground. Of considerable concern is the plan to move from centralized control and responsibility for aircraft separation to decentralized control and distributed responsibility.

Because of the impending NAS overload, research on distributed air-ground concepts has been undertaken to identify and develop air-ground concepts to ensure that free-flight operations are implemented successfully. The underlying concept evaluated in this effort was based on three principles: (1) aircraft pilots should always broadcast intent information in the form of current flight plans; (2) all flight plans should be deconflicted to the maximum extent possible (in this case out to a range of 120 nautical miles); and (3) the interface for flightpath replanning tools should be graphical and impose low workload.

A full-mission air-ground simulation was conducted in the Ames' Crew Vehicle Systems Research Facility in support of this effort. Its goal was to evaluate the effect of advanced displays with intent information (for example, four-dimensional (4-D) flight plans) on flight crew and ATC performance during limited free-flight operations. To assess the value of 4-D intent information, flight crews performed real-time, strategic flightpath replanning with and without access to graphically presented 3-D flight plan information about surrounding traffic during en route operations. To support the replanning task, flight crews used an enhanced cockpit situation display (CSD) that depicted surrounding traffic, a dynamic 4-D predictor symbology, and tools that alerted the crew to impending losses of separation (fig. 1). The conflict-alert tool was color-coded (blue, white, and green) to reflect aircraft and portions of flight plans that were above, at, or below own-ship altitude. The CSD also contained a graphical route assessment and replanning tool used to develop alternative (deconflicted) flight plans (fig. 2). Once developed, modified flight plans were submitted electronically for approval and, upon approval, automatically loaded into the autopilot and data linked to all surrounding traffic. The study also examined two levels of ATC authority: (1) Limited Authority, at which level ATC intervened only when a loss of separation was imminent; and (2) Full Authority, at which level ATC ran the sector as they would normally.

The results suggest that flight crews with advanced 4-D flight plan information can perform strategic self-separation during operations in densely populated traffic environments. And, when ATC remains in the information

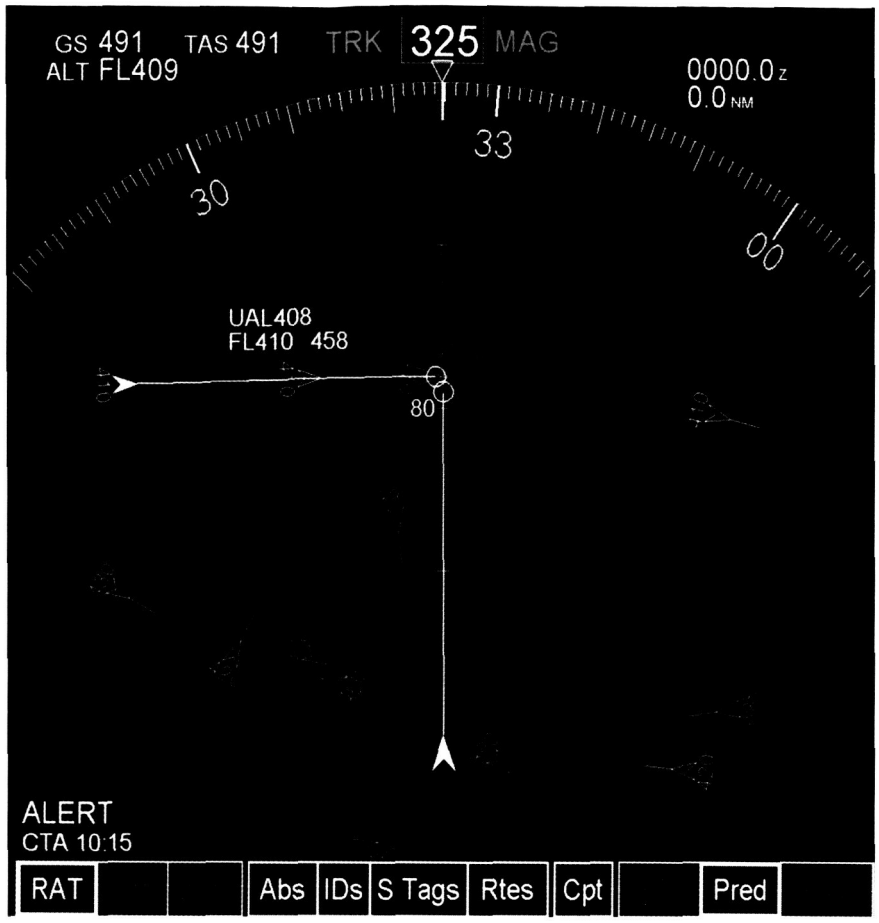

Fig. 1. Detection of a conflict on the CSD.

and approval loop, strategic self-separation performed by flight crews is not disruptive to normal ATC sector operations. The results also showed that crews with access to 4-D flight plan information were more efficient, made smaller deviations for traffic and fewer total flight plan modifications, and experienced lower workload. Crew evaluations of 3-D and 4-D traffic information, of the display declutter features, and of the advanced flight replanning tools were very positive, although the input devices (knobs/dials or touch pads) were not as highly rated as the display itself.

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